The online coupled meso scale climate-chemistry model MCCM – a modeling tool for short as well as for climate periods

Peter Suppan, Renate Forkel, Edwin Haas

Institute for Meteorology and Climate Research
Atmospheric Environmental Research (IMK-IFU)
Garmisch-Partenkirchen / Germany

Overview

- Introduction to the modeling system MCCM
- Short outline about the type of applications
- Examples and results
- Summary

Online coupled meso scale climate chemistry model

Meteorological part

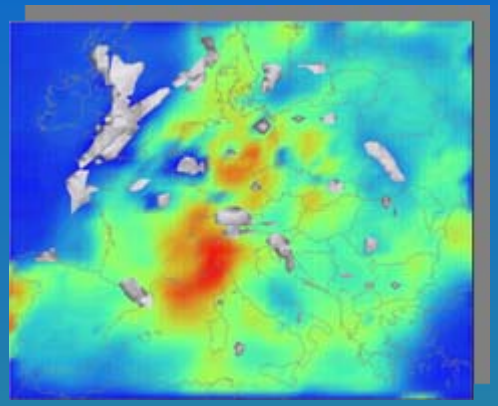
- Based on MM5
- Non-hydrostatic
- Nesting capability
- Soil and snow model

Chemistry part

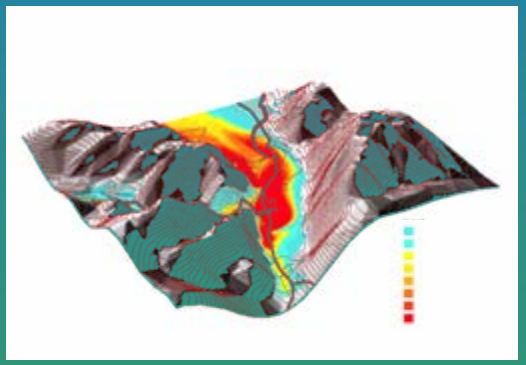
- RADM2 / RACM chemistry
- KPP preprocessor for chemical mechanisms
- Photolysis model
- Aerosol module (SORGAM)
- Biogenic emission module

Output:
Fields of temperature, humidity, cloud water and ice, rain water, snow, photolysis frequencies, concentrations of chemical compounds in the gas and particle phase, snow height …

Mesoscale-Climate-Chemistry-Model (MCCM)



regional



local

Observations

Orography
Land use
Soil Texture

Anthropogenic
Emissions

Global Weather
forecast models

Global
Climate Models

Analysis

Interpolation

Meteorological
Data Assimilation

Biogenic
Emissions

MCCM (MM5/chem)
Meteorology, Climate, Aerosols,
Air Chemistry, Soil-Vegetation

Runoff / Routing
Model (e.g. WASIM)

Detailed hydrological
Model

Dynamic Vegetation
Model (MOBILE)

Bio-Geo-Chemistry
Model

Micro-scale Model
(e.g. GRAL)

Simulation
of Air Quality

Simulation of
Regional Climate

Air Pollution
Control Strategies

Critical Levels
and Loads

Climate Changes
and Air Quality

Extreme
Events

Soil-Vegetation-
Atmosphere
Feedback Effects

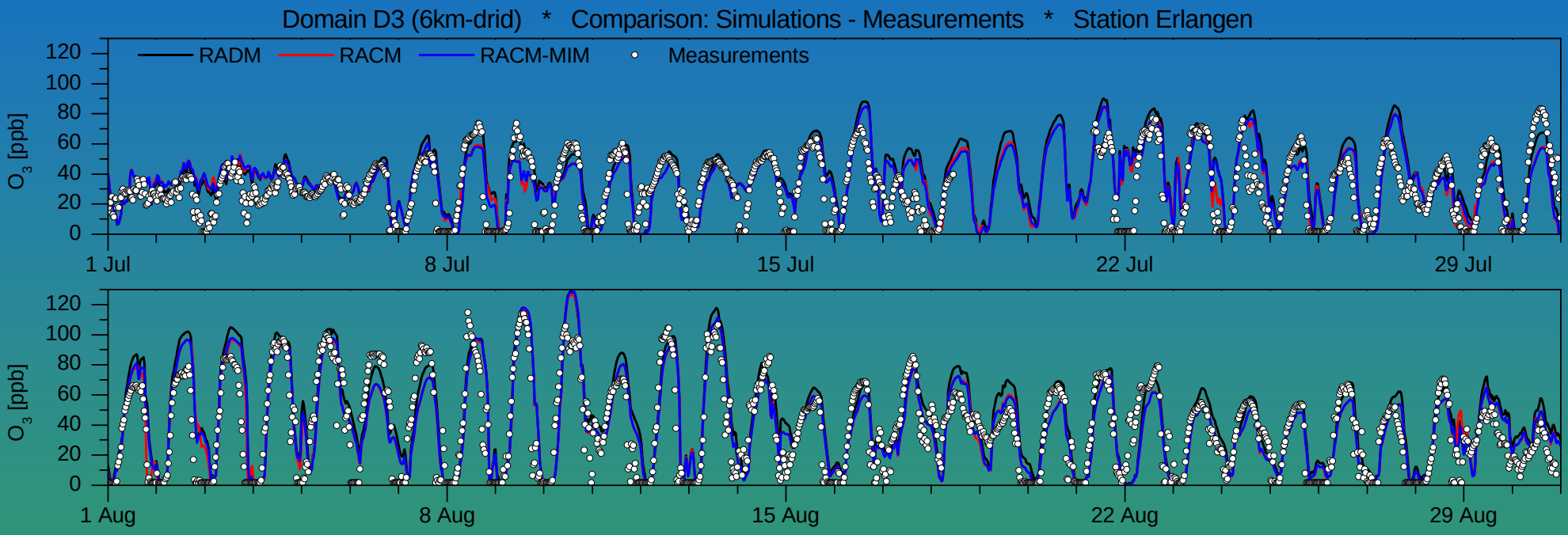
Chemistry Mechanisms

- **RADM2 (Stockwell et al. 1990)**
  63 chemical species, 21 photolysis reactions and 136 chemical reactions of higher order
- **RACM (Stockwell et al. 1997)**
  77 chemical species, 23 photolysis reactions and 214 chemical reactions of higher order
- **RACM-MIM (Geiger et al. 2003)**
  84 chemical species, 23 photolysis reactions and 221 chemical reactions of higher order
  (based on MIM-Isoprene-Mechanism; this mechanism reflects an advanced description of the chemistry of biogenic ozone precursors like isoprene and others

Applications

- Evaluation studies about chemical schemes and numerical methods
  (→ Bavaria)
- Short time simulations, validation, comparison, strategies and scenarios of air quality studies
  (→ Mexico City, Santiago de Chile, Munich, Augsburg, Berlin)
- Long time simulations with the background on annual thresholds
  (→ Alpine region)
- Operational forecast for O_3 and PM_{10}
  (→ Southern Germany, Bavaria, Southern Austria)
- Climate-chemistry simulations for present and future climate
  (→ Southern Germany, Mexico)

Evaluation Studies – Chemical Mechanisms



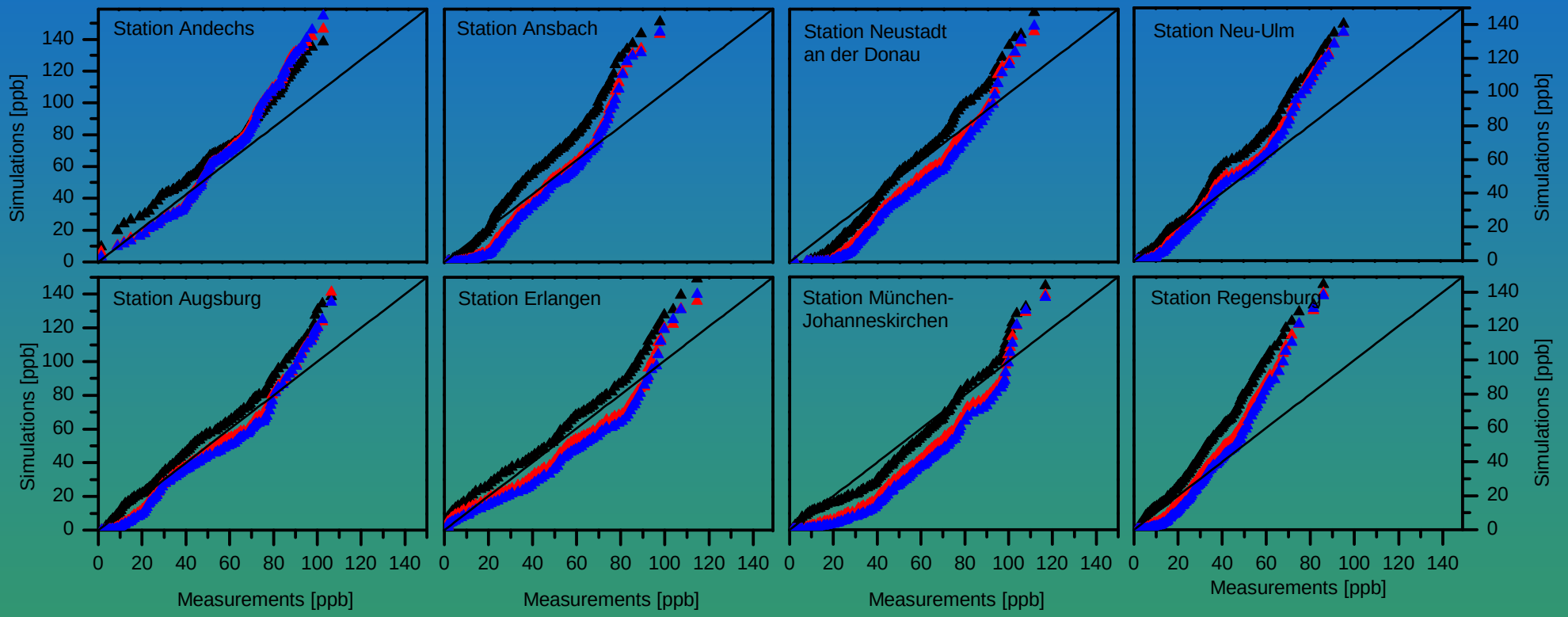
PhD thesis / Edwin Haas 2007

Setup: 54-18-6-2 km grid
2 month period
Southern Germany

Evaluation Studies – Advection Schemes

D3: Quantile-Quantile-Plot

▲ MPDATA ▲ BOTTM ▲ BOTTP

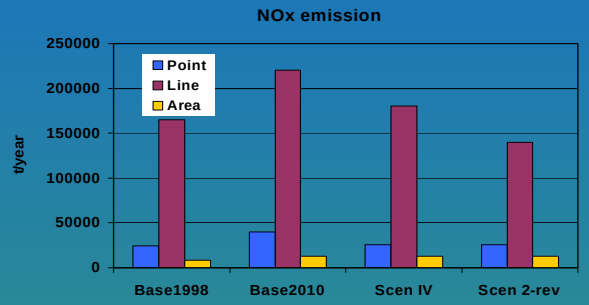


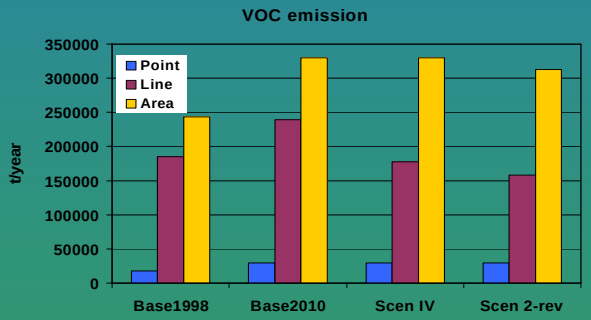
Setup: 54-18-6-2 km grid
10 days period
Southern Germany

PhD thesis / Edwin Haas 2007

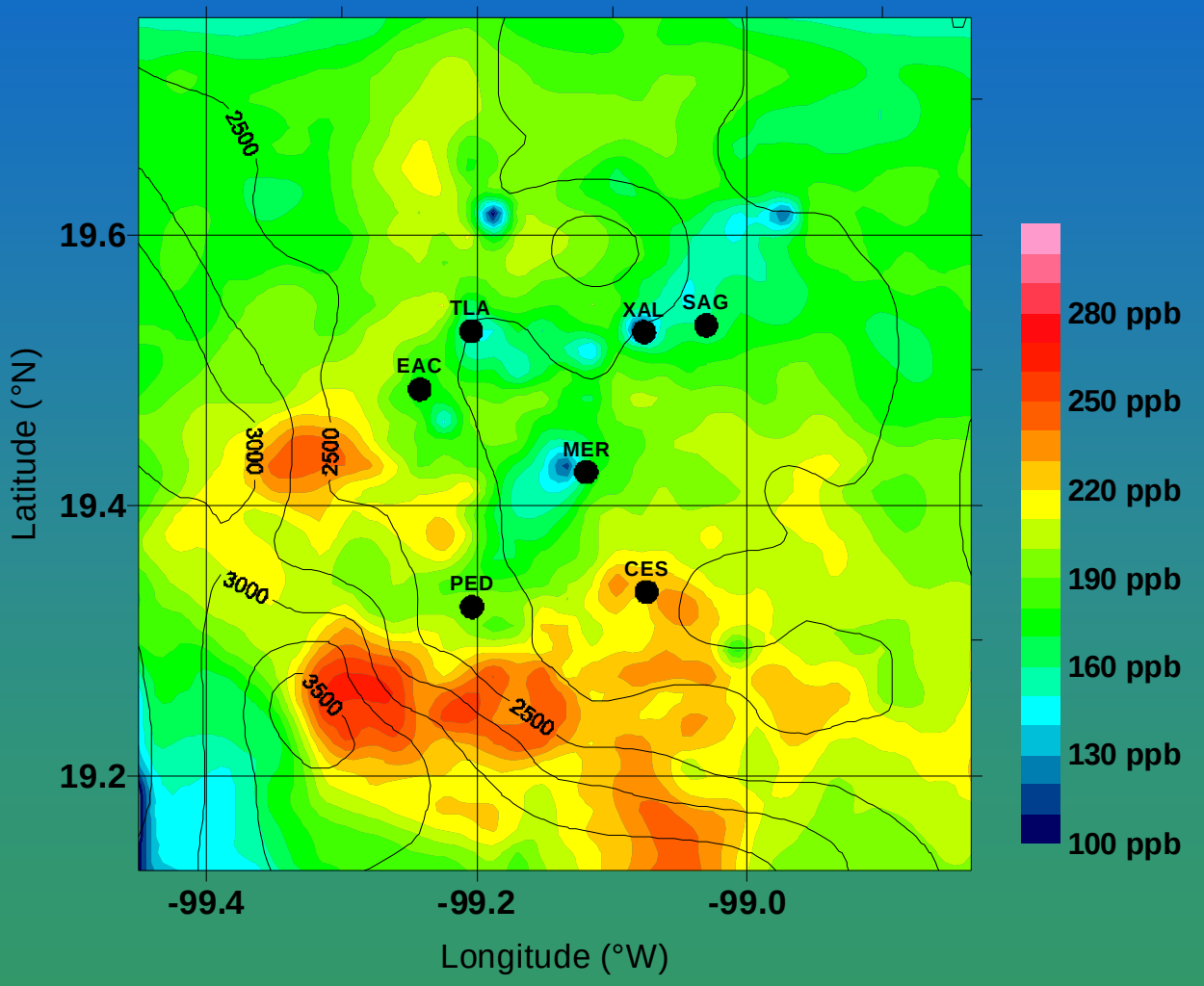
Air Quality Studies - Scenarios

O_3-concentrations in 2010



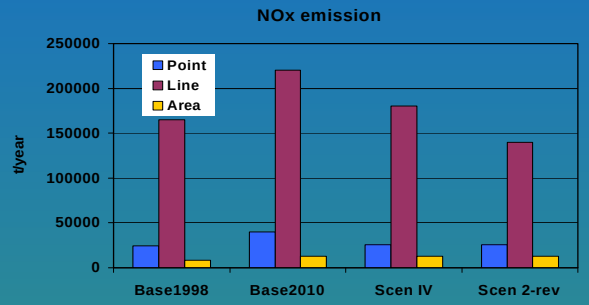


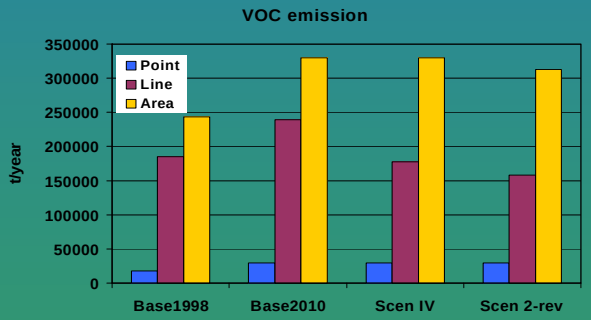
Setup: 18-6-2 km grid
days period
Mexico City



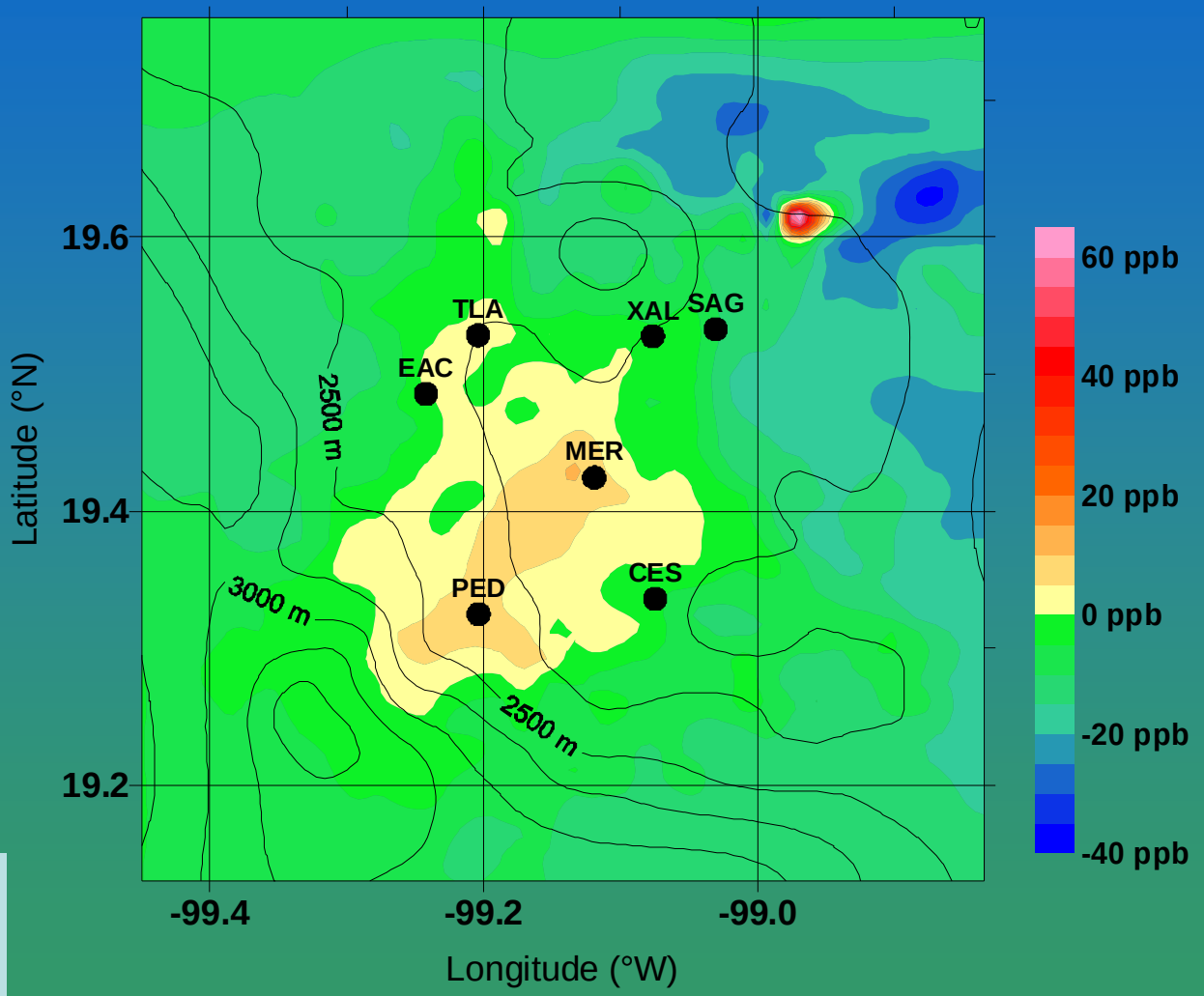
Air Quality Studies - Scenarios

O_3-Difference in 2010





Setup: 18-6-2 km grid
days period
Mexico City



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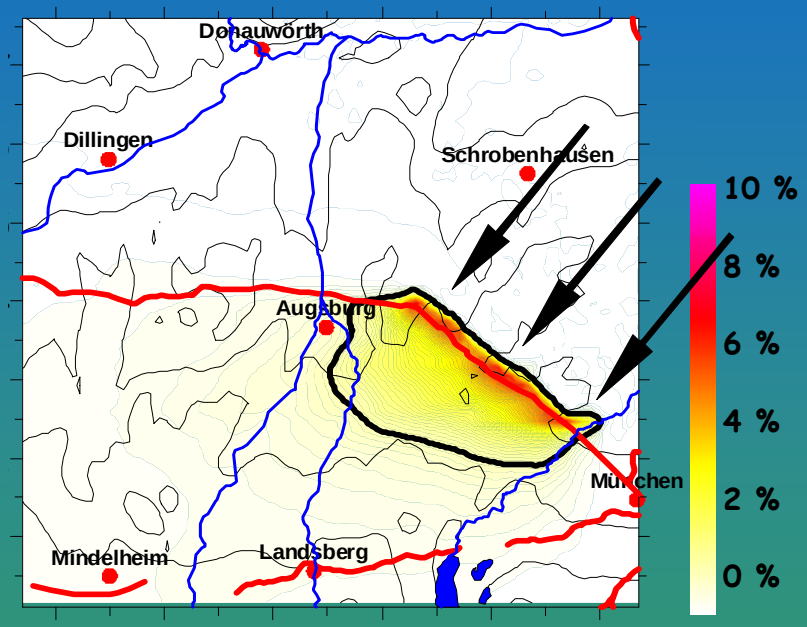
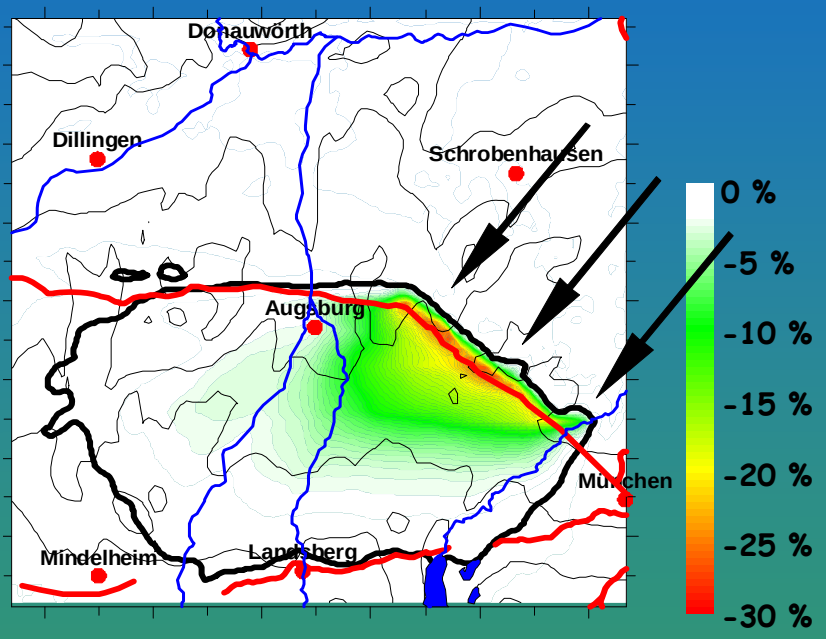
Air Quality Studies – Emission Strategies



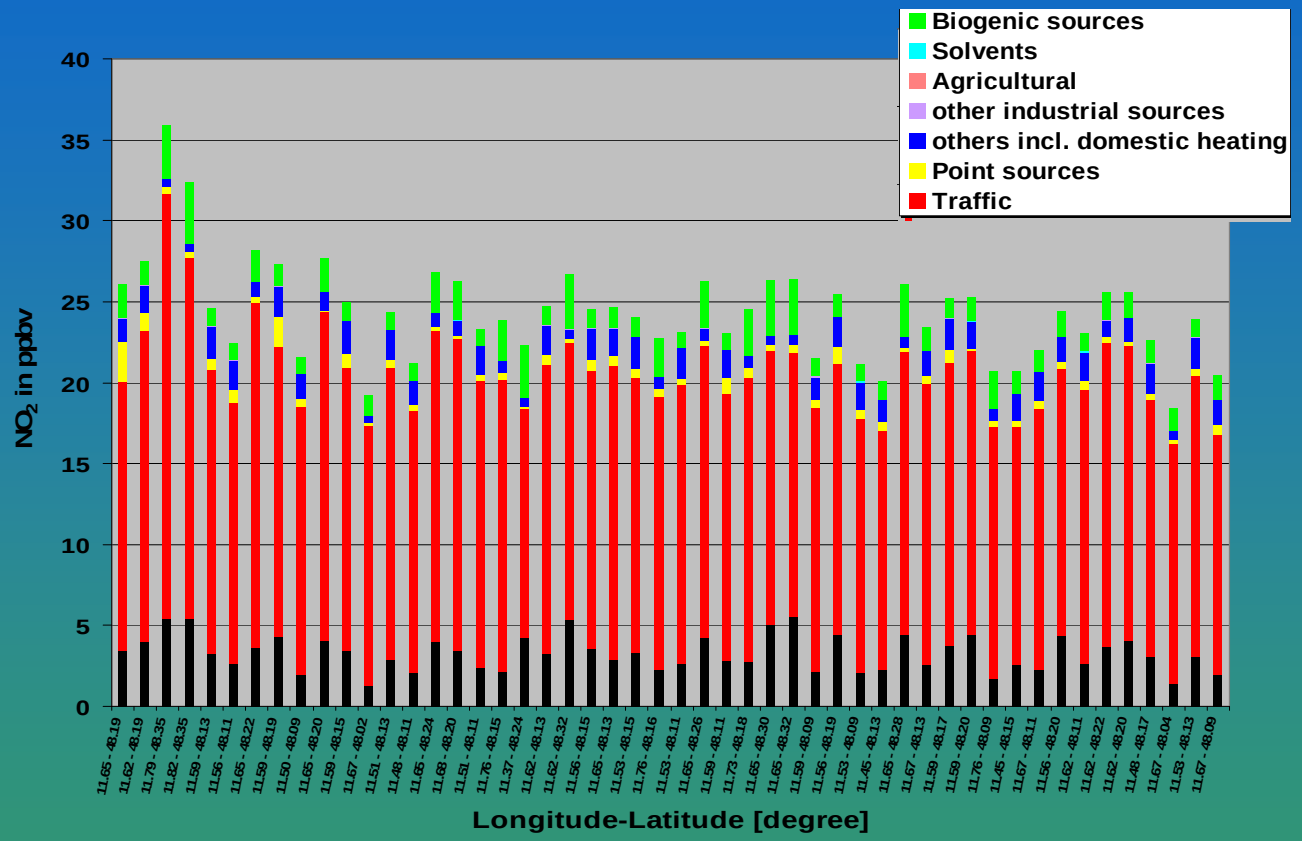
O_3 change



NO_2 change

Setup: 27-9-3-1 km grid
4 days period
Southern Germany

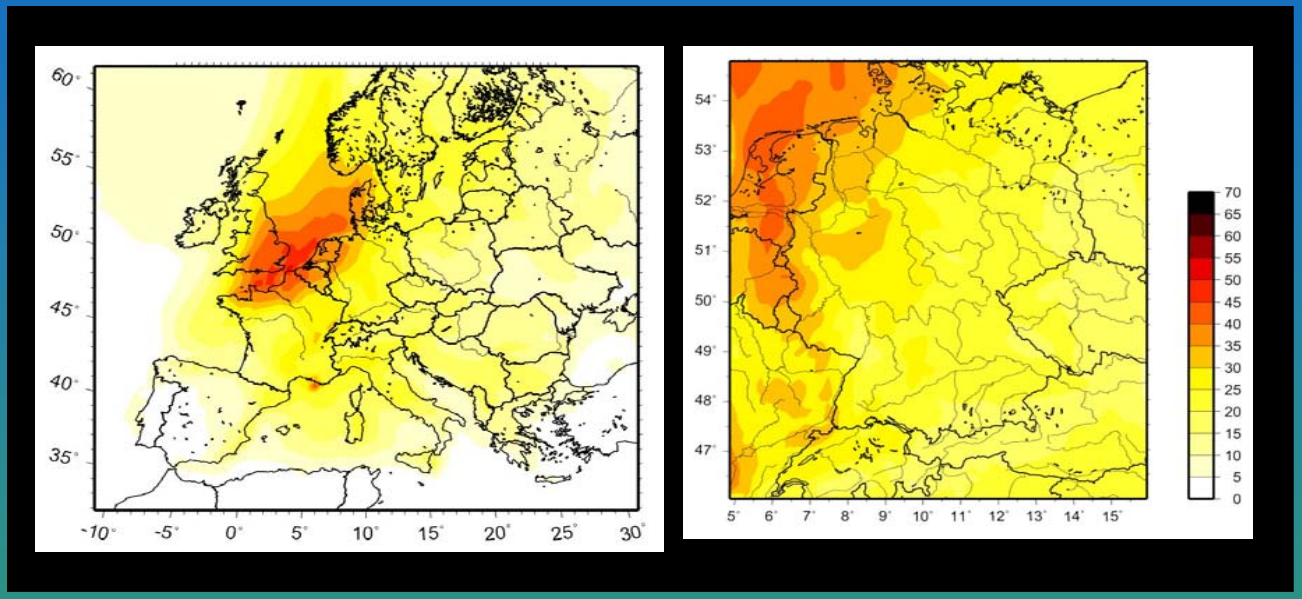
Air Quality Studies - Methodology

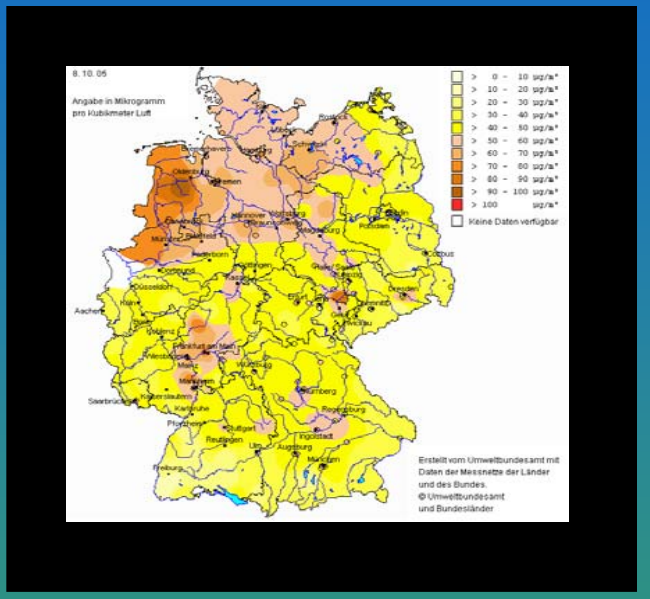


Source-receptor analysis for NO_2 within the conurbation of Munich

Setup: 54-18-6-2 km grid
5 days period
Southern Germany

Operational Forecast e.g. PM_{10}





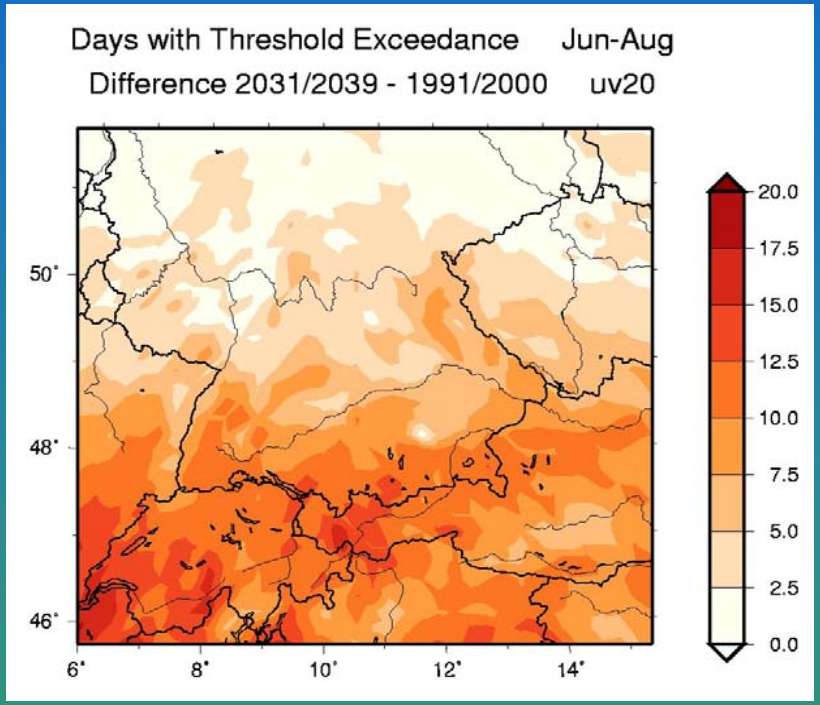
1 day forecast: 8th Oct. 2005

Domain 1: 60 km **Domain 2: 15 km**

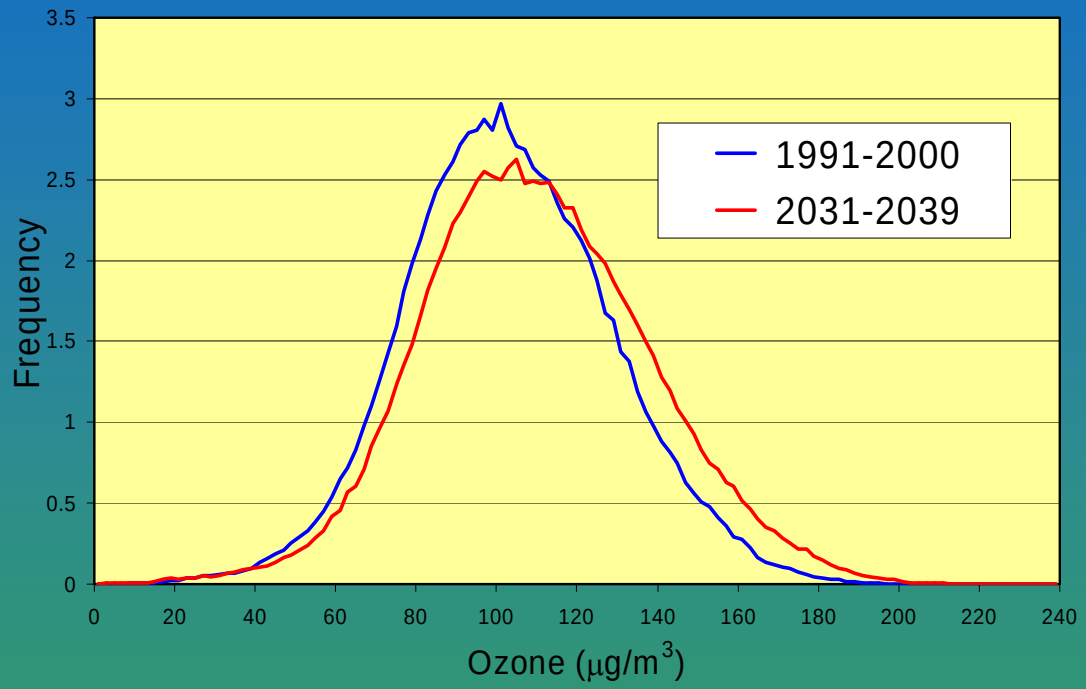
Measurements: 8th Oct. 2005 (Source: UBA)

Setup: 60-15 km grid
3 days forecast
Germany

Climate-Chemistry Simulations – Air Quality



Threshold exceedances in the future



Distribution of daily O_3 maximum

Setup: 60-20 km grid
2x10 years period
Southern Germany

Summary

- Meso-scale Climate-Chemistry Model (MCCM) ……
  - ✓ based on a well known and validated meteorological model (→ MM5)
  - ✓ performs with validated chemistry mechanisms
  - ✓ short- and long term simulations, assessment of emission strategies, forecast, climate impact assessment
  - ✓ Regional and urban areas (e.g. alpine environments; urbanized conglomerations)

Remarks and Outlook

- Modeling tools are only a part of a integrative description of the air quality
- Models results are only as good as its input data
- Model diversity against community model

- Focus on climate-chemistry simulations with emphasis on urban conglomerations
- Model coupling within the compartments of the bio-, hydro- and atmosphere

Thank you for your attention